ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at: www.ijdsir.com

Volume – 4, Issue – 3, May - 2021, Page No. : 549 - 555

Automation in Restorative Dentistry: A Revolutionary Concept

[1]Dr. Pradeep Kumar, Reader, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Yenepoya Deemed to be University, Deralakatte, Mangalore, Karnataka, India.

[2]Dr. Vemula Akhila, Post graduate student, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Yenepoya Deemed to be University, Deralakatte, Mangalore, Karnataka, India.

[3]Dr. Prathap M.S, Professor ,Head of the Department, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Yenepoya Deemed to be University, Deralakatte, Mangalore, Karnataka, India.

[4]Dr. Nishi Jayasheelan, Senior Lecturer, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Yenepoya Deemed to be University, Deralakatte, Mangalore, Karnataka, India.

Corresponding Author: Dr. Vemula Akhila, Post graduate student, Department of Conservative Dentistry and Endodontics, Yenepoya Dental College, Yenepoya Deemed to be University, Deralakatte, Mangalore, Karnataka, India.

Citation of this Article: Dr. Pradeep Kumar, Dr. Vemula Akhila, Dr. Prathap M.S, Dr. Nishi Jayasheelan, "Automation in Restorative Dentistry: A Revolutionary Concept", IJDSIR- May - 2021, Vol. – 4, Issue - 3, P. No. 549 – 555.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Robotics is an interdisciplinary research area at the interface of computer science and engineering. Robotics involves design, construction, operation and use of robots. Robots are man-made artificial intelligent devices used in various fields of day to day life. Use of robotics in dentistry is a revolutionary concept which is still under research. The main objective of robotics in dentistry is to modernize the traditional treatment, from "manual art" to "science-based automation". The first application of nano-robotics was in medicine to identify and destroy cancer cells. It is important to provide patient education and awareness of various technologies available in the fields of dentistry. The main aim of this paper is to review current research in the field of manufacture and application of robotics in operative dentistry and endodontics.

Keywords: automation, dental robots, nanotechnology, endo micro-robots, artificial intelligence, nanodentistry, digital dentistry

Search Strategy

A systematic review (SR) was performed by using electronic databases (PubMed, Google Scholar, Science direct etc.,) The database search employed the following key words: dental robots, automation, artificial intelligence, endo micro-robot, nanotechnology, Nano dentistry. Inclusion criteria were articles published in English from 2006 to 2020.

Introduction

Robotics is the branch of technology that deals with design, construction, operation and application of robots as well as computer systems for their control, sensory feedback and information processing[1]. The term robotics was first coined by the writer Issac Asimov in his science fiction book, I robot, published in 1950[1]. According to the robot institute of America, a robot is defined as "a reprogrammable, multifunctional manipulator designed to move materials, parts, tools or specialized devices through various programmed motions for the performance of a variety of tasks[2]. Different types of robots are already available in the market for various industrial applications[3]. Robots are small entities introduced in the field of medicine and dentistry to increase precision, quality and safety of various procedures[4]. Nanotechnology is a field of applied science and technology which deals with individual atoms and molecules to construct functional structures[5]. With growing interest of application in nanotechnology, dentistry is leading to the emergence of a new field called nanodentistry, which deals with nanomaterials, biotechnology and dental nanorobotics[5]. *Nanodentistry* is defined as the science and technology of diagnosing, treating and preventing oral and dental diseases, relieving pain, preserving and improving dental health using nanostructured materials[6]. Nanorobotics help dentists in various fields like inducing anesthesia, plaque removal, tooth repositioning, tooth preparation, treating dentin hypersensitivity, remineralization of incipient lesions, restoration of cavities, bleaching and in various fields of endodontics such as access opening, enhancing cleaning and shaping procedures and obturation techniques[7].

Robots in Dentistry

Nano-robot is a tiny machine designed with artificial intelligence to perform a specific task or tasks repeatedly with precision at nano-dimensions. Nano-robots might function at the atomic or molecular level to build devices, machines, or circuits, a process known as molecular manufacturing5. Nano-robot functions may be controlled by a board nano-computer that executes preprogrammed instructions in response to local sensor stimuli[8].

Figure-1: Dental Robot[9]

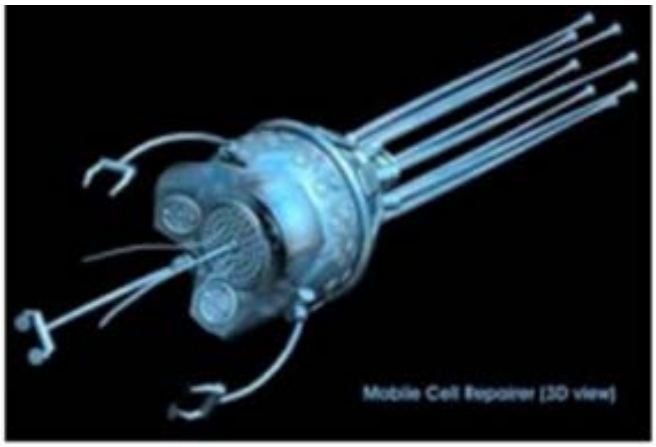

Figure 2: Nanorobot[10]

Nano-robots are microscopic in size and it would probably be required in very large numbers to work together and perform microscopic and macroscopic tasks[9].

Dental training patient robot

Currently, patient robots are being used for dental therapy training. The so - called "phantoms" consisting of a simple functional cephalic region and an arrangement of teeth are used for clinical training[11,1].

Realistic human-like robot

Show hanako: In the capital of Japan, Showa University mingled with the robotics company named TMSK in order to manufacture a realistic robot which behaved exactly like a human in its gestures and responses which helped the dental students to learn more efficiently[12,11.]

Geminoid DK: It is the first robot in a series based on personalities outside Japan. These robots are called geminoids and are remote controlled with advanced motion capture technology allowing the machine to copy the facial expressions and various head motions[11.]

Simroid: This robot was developed at The Nippon Dental University Kokoro and it is used to train dentists in various fields. It is an upgrade of simuloid, which is a less efficient robot which was developed in 2007. Simroid robot is developed in order to provide an emotional feedback to dentists especially pain and discomfort and also to respond and react to questions and commands and finally rate and evaluate their treatment[2].

Robot assistant: The authors investigated and invented the possibility of active robotic support system during treatments for handling of instruments via a multi-modal communication framework that aims at a dentist as assistant. It comprises of bilateral physical human–robot interaction, touch display input, speech input and visual gestures. In their approach they used a safe collaborative and sensitive robot and conducted a user-study to explore the feasibility of different human–robot interaction modalities in dentistry[3].

Figure-3: Concept of dental patient robot initiated in Japan[11]

Nanorobotic dentifrice (dentifrobots): Nano-robotic dentifrices, which are available in mouthwash or toothpaste form, when on contact with the tooth surface scroll over the supra-gingival and sub-gingival surfaces, once a day, removing the attached organic matter and debris on the tooth surface[13,9]. They can also detect the cariogenic bacteria in the biofilm and maintain the normal ecosystem of the oral cavity[9,5].

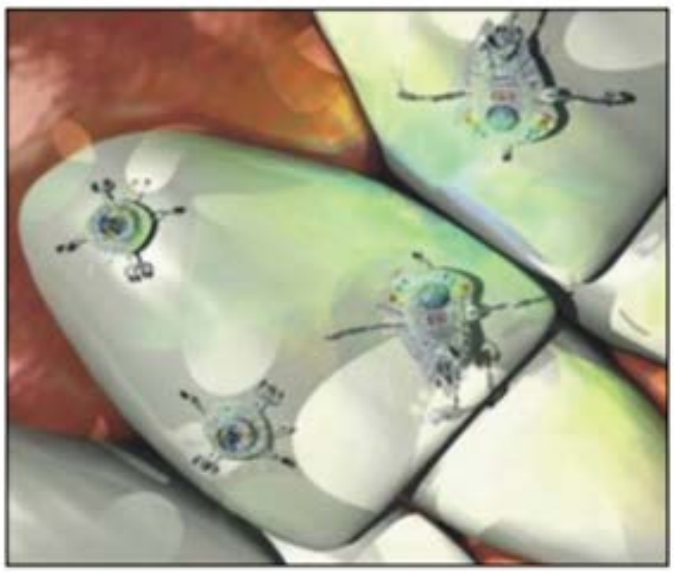

Figure 4: nanorobot in dentrifice[9].

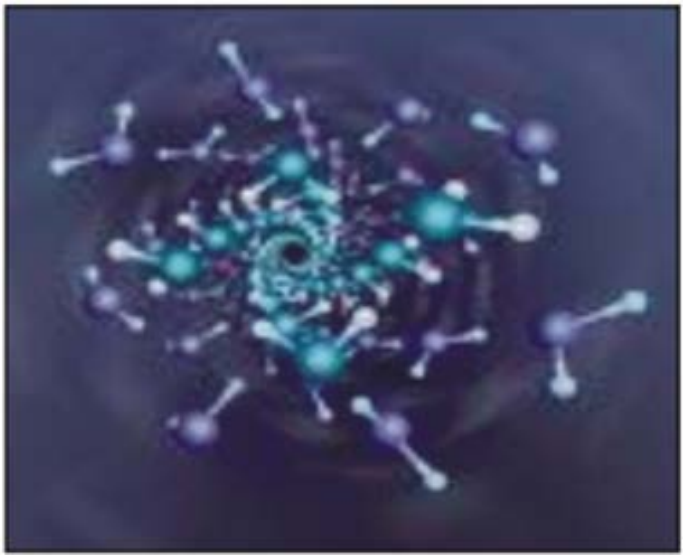

Figure 5: Nano robot in anaesthetic solution[9].

Inducing anesthesia: A colloidal suspension contains millions of active analgesic micron sized dental nanorobots which are installed on the patient`s gingiva. After contacting with the surface of the crown or mucosa, these ambulating nanorobots reach dentin by migrating into the gingival sulcus and pass painlessly through the lamina propria[5]. Upon reaching the dentin, they enter the dentinal tubules upto 1-4 µm in depth and proceed towards the pulp guided by a combination of chemical gradients, temperature differences and positional navigation under nanocomputer control[9].

The migration of nanorobots from tooth surface to the pulp occurs in 100seconds. Once installed in the pulp, they establish control over nerve impulses. Analgesic nanorobots commanded by the dentist shut down all sensitivity in any particular tooth requiring treatment. When the dentist presses the hand held control, the selected tooth is immediately anaesthetized[5]. After the procedure is completed, the dentist orders the nanorobots to restore all sensation and egress from the tooth by similar pathways used to ingress[9].

Nanorobot analgesia offers greater patient comfort, reduced anxiety, no needles, greater selectivity, controllability of analgesic effect; fast and completely reversible action; avoidance of side effects and complications.

Dentin hypersensitivity: Dentin hypersensitivity is a pathological phenomenon caused by pressure transmitted hydro-dynamically to the pulp. Reconstructive dental nano-robots selectively and precisely occlude specific dentinal tubules within minutes, offering patients a quick and permanent cure from hypersensitivity[7].

Many therapeutic agents provide temporary relief for this common painful condition, but reconstructive dental nanorobots, offer patients a quick and permanent cure within minutes[9.]

Cavity preparation and restoration: Multiple Nanorobots working on the teeth in unison, invisible to the naked eye, may be used for cavity preparation and restoration of teeth[11.] Cavity preparation is very precise and is restricted to demineralized enamel and dentin with perfect removal of caries and maintenance of healthy tooth structure, proper retention and resistance features far beyond the skill of a most experienced clinicians[9,1.]

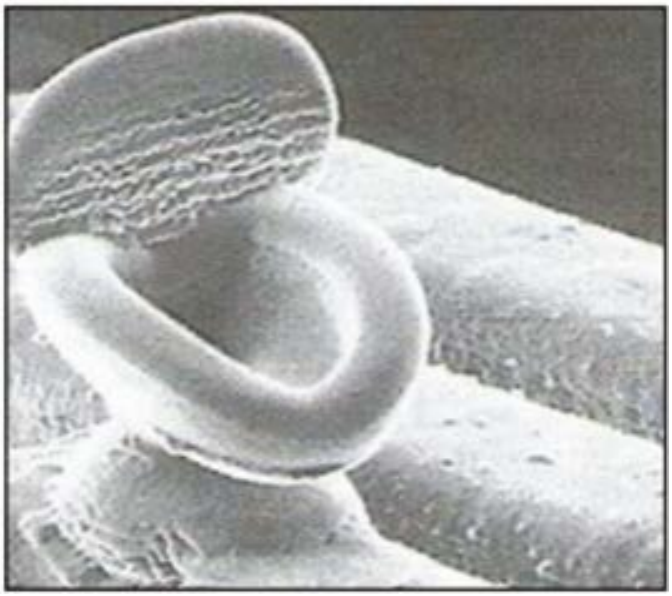

Fig. 6: Hypersensitivity curing Nano robots in dentinal tubule[9].

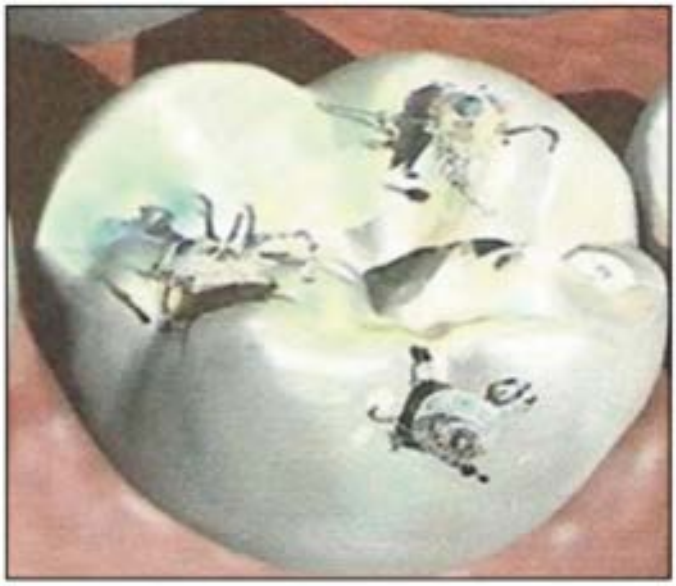

Fig. 7: Cavity preparation and restoration using nanorobot[9].

Tooth preparation: Robots prepare teeth according to the confirmed virtual preparation designs. Thus, a robotic tooth preparation system facilitates the preservation of tooth structure with high accuracy and precision[14].

A study conducted by Fusong Yuan et.al 2019 showed that robotic automated tooth preparation is superior to manual tooth preparation as reported in the literature with respect to efficiency and accuracy of ablating[15].

Endo micro-robot: Micro endodontic robots can provide safe, accurate and reliable root canal treatment for patients by preventing problems identified with conventional techniques such as inadequate opening and overzealous tooth removal[4]. With online monitoring an intelligent management, this machine will perform the automatic probing, drilling, cleaning and filling of the root canals [2,12].

Specific objectives of micro-robots include

1. Reducing the reliance on the skills of dentist.
2. Minimizing human error
3. Offering a method for precise diagnosis and treatment[4].

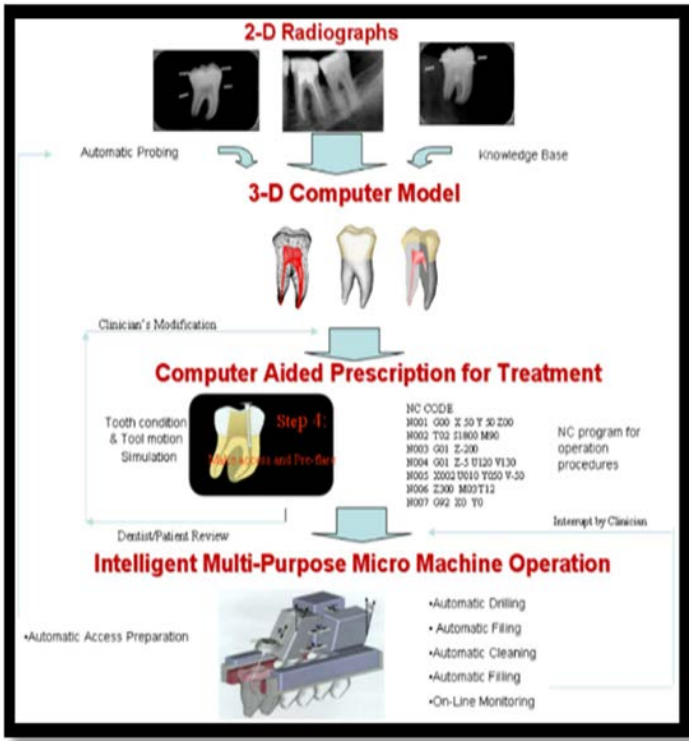

Figure 8: Summary of automated root canal treatent[4]

Advantages and Disadvantages

Dental robots have several advantages and dis-advantages. They are:

Advantages

High accuracy and precision.

1. Stable, anchored and untiring that can be used repeatedly without rest.
2. Ability to judge quantitative information fed into the system[16].

Dis-Advantages

1. No judgment of the clinical situation and hence unable to process any qualitative information.
2. Continuous monitoring of an experienced dentist is always required.
3. These devices are very expensive and out of reach for the common man[16].
4. The design of the nano-robot is very complicated and hence difficult to customize and co-ordinate the tooth and robot interface[17].

The art of digital dentistry — now and in the near future

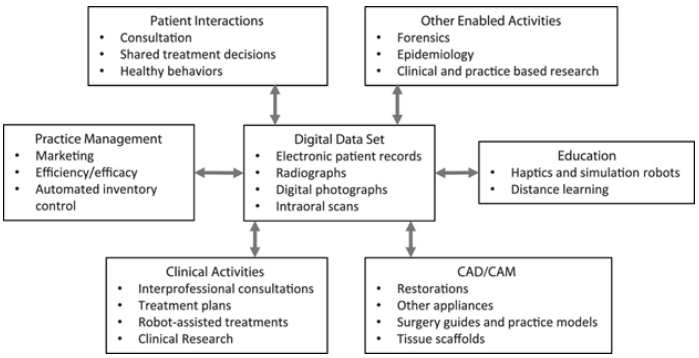

Figure 9: The art of digital dentistry[18]

Conclusion

Robotics is a quantum leap in the field of technology and its applications in dentistry are immense and extensive. With the incorporation of Artifical Intelligence to our day-to-day clinical practice, there are exceptional and surprising improvements in the precision of our treatments. Hence, it is very important for all clinicians to have basic knowledge and training with these advancing technologies. However, it also requires a lot of research and financial support for the actual implementation of robots in our clinical practice. In no way can artifical intelligence replace humans, but their integration in our field leads to a successful and stress-free practice in future.

References

1. Das PK, Hari S, Nair S, Kumar A. Robotics in dentistry. Indian Journal of Oral Health and Research. 2019 Jul 1;5(2):37.
2. Kumar P, Dixit P, Kalaivani V, Rajapandian K. Future advances in robotic dentistry. J Dent Health Oral Disord Ther. 2017;7(3):00241.
3. Grischke J, Johannsmeier L, Eich L, Griga L, Haddadin S. Dentronics: Towards robotics and artificial intelligence in dentistry. Dental Materials. 2020 Apr 27.
4. Neha S, Shantipriya P, Shekhar K, Smitha R, Ravichandra C, Sindhura G. Micro Robot- A Revolution in Endodontics. Ann. Int. Med. Den. Res. 2017; 3(4): DE06-DE08.
5. Dash s, kallepalli s. Influence of nanotechnology in operative dentistry and endodontics-think" big", act" small". Journal of Advanced Medical and Dental Sciences Research. 2015 Oct 1;3(4):51.
6. Sneha S. Mantri, Shivkumar P. Mantri. The nano era in dentistry. Journal of Natural Science, Biology and Medicine 2013;4:39-44
7. Freitas Jr RA, JD B, Schleyer TL, Greenstein G. 1559 Nanodentistry
8. Mallanagouda P, Dhoom S. M, Sowjanya G. Future impact of nanotechnology on medicine and dentistry. J. Ind. Soc. Periodontol. 2008;12:34-40
9. Sujatha V, Suresh M, Mahalaxmi S. Nanorobotics-A futuristic approach. SRM Univ J Dent Sci. 2010 Jun;1:86-90.
10. Uriarte SL. Nanorobots. online] Technical report Escuela Superior De Ingenieros De Bilbao, Bilboko Ingeniarien Goi Eskola, Universidad Del País Vasco/Euskal Herriko Unibersitatea. 2011,
11. Rawtiya M, Verma K, Sethi P, Loomba K. Application of robotics in dentistry. Indian J Dent Adv. 2014 Oct 1;6(4):1700-6.
12. Bhat BD, Bhandary S, Naik R, Shetty D. Robotics in dentistry: Fiction or reality. Journal of Dental Research and Review. 2017 Jul 1;4(3):67.
13. Kumar SR, Vijayalakshmi R. Nanotechnology in dentistry. Indian J Dent Res. 2006 Apr 1;17(2):62-5.
14. Otani T, Raigrodski AJ, Mancl L, Kanuma I, Rosen J. In vitro evaluation of accuracy and precision of automated robotic tooth preparation system for porcelain laminate veneers. The Journal of prosthetic dentistry. 2015 Aug 1;114(2):229-35.

15. Yuan F, Lyu P. A preliminary study on a tooth preparation robot. Advances in Applied Ceramics. 2020 Aug 17;119(5-6):332-7.
16. Sreelekshmi S, Varghese K, Abraham JP, Jaysa JJ. Applications Of Robotics In Prosthodontics–A Review. Int J Innovat Res Adv Stud. 2017;4(5):38-41.
17. Upadhyay VP, Sonawat M, Singh S, Merugu R. Nano robots in medicine: a review. International Journal of Engineering Technologies and Management Research. 2017;4(12):27-37.
18. Rekow ED. Digital dentistry: The new state of the art—Is it disruptive or destructive?. Dental Materials. 2020 Jan 1;36(1):9-24.